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## (54) IMPROVEMENTS IN OR RELATING TO PROCESSES FOR PRODUCING MATERIAL BY BONDING EXPANDED PLASTICS GRANULES

(71) I, THE SECRETARY OF STATE FOR DEFENCE, Whitehall, London SW1A 2HB do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to processes for producing material by bonding together expanded plastics granules and to materials produced by such processes. It has one application in light-weight packaging material produced by moulding expanded polystyrene (EPS) granules.

The use of EPS packaging material is well known, the granules normally being moulded to match the outer shape of the article it is intended to protect. A disadvantage of existing EPS materials for some purposes is that polystyrene is a good electrical insulator and can therefore become charged with static electricity. This can be dangerous if the protected article comprises, for example, an inflammable or explosive substance.

The present invention overcomes this problem by surface-treating the granules prior to moulding in such a way that the moulded material becomes electrically conducting. The present invention also embraces forms of surface-treatment producing useful effects additional to electrical conductivity. Nor is it limited to processes involving moulding.

According to the present invention a process for producing material which comprises expanded polymer granules bonded together, each said granule having been produced by expanding a smaller granule either before or during the present process, comprises the step of coating the granule surfaces, prior to bonding, with a solution or suspension which is compatible (as hereinafter defined) with the granules and which, when dried, forms an adherent film on the granules said solution or suspension incorporating an electrically conducting substance, either as a solute or as finely divided particles, which becomes bound with the dry adherent film.

The granules may be of expanded polystyrene. The solution or suspension may, for example, comprise polyvinyl alcohol (PVA) or polychloroprene dissolved or suspended in known liquid vehicles for such substances, eg as aqueous emulsions; organic liquid vehicles can also be used. The liquid vehicle must, however, be compatible with the granule material, ie it must not degenerate the material by dissolving it or otherwise. Aqueous vehicles have the advantage of being non-inflammable. Natural and synthetic rubber latices can also be used, eg styrene butadiene synthetic rubber latex. Water extended epoxies and polyesters may also be usable as coating materials; a hard shell-like coating can thereby be produced to modify the physical properties of the bonded material.

The electrically conducting substances incorporated in the solution or suspension may comprise particles of carbon, eg as graphite, or of a metal such as silver, or of a chemical compound such as stearamido propyldimethyl 2-hydroxyethyl ammonium dihydrogen phosphate. When using carbon, especially to produce material in the anti-static range of resistance as specified in BS 2050, it is preferred to use a mixture of graphite powder and colloidal graphite.

The coating may be applied by tumbling the granules in the solution or suspension, or wetting them therewith. The coating may be allowed to dry before bonding the granules, or they may be bonded wet.

In the production of expanded plastics (eg EPS) mouldings, it is customary to fill the mould with partially expanded granules (known as "pre-expanded" granules or "beads") which are then fully expanded and bonded together by the application of heat, eg as live steam. In applying the present invention to the production of such mouldings, the solution or suspension can be applied to the granules in the pre-expanded state.

Customary moulding techniques and conditions, as aforesaid, for dry uncoated pre-expanded granules can be used to bond thus-coated pre-expanded granules into

material formed in required shapes, eg for use as packaging, using either wet or dry granules. The use of dry granules is usually more convenient because they are free-flowing. Inspection of EPS mouldings thus made using PVA emulsion-coated granules indicates that proportions of three kinds of inter-granule bonding may be formed, viz coating-coating, plastic-plastic and coating-plastic.

Alternatively the solution or suspension can be applied to the wholly unexpanded granules (in which form they are sometimes known in the art as "sugar".) The coated unexpanded granules are then expanded in the usual way to the pre-expanded state before filling the mould and applying heat thereto.

Coating the unexpanded granules has the advantages for large-scale use (a) that there is less volume of granules to coat for a given quantity of molded material and (b) that the coated unexpanded granules can be stored for a prolonged period whereas pre-expanded granules are known to have a relatively short useful life, eg up to about 2 days. The tensile and compressive properties of the thus-produced material are not substantially different from material produced by coating the pre-expanded granules. The coated unexpanded granules can be expanded to the pre-expanded state by heating in the usual manner while still wet, or can first be dried.

Furthermore, by using certain coating solutions or suspensions the dried pre-expanded granules retain a surface tackiness which enables the granules to be used as a loose fill which will bond together at room temperature under only light pressure to form a solid, non-messy, packaging material effectively moulded *in situ*. Examples of coatings which provide granules usable in the latter way are natural and synthetic rubber aqueous emulsions. Normally such loose-fill packings are not expanded after filling.

Syntactic materials coated with the solution or suspension can be included with the plastics granules to give desirable properties, such as increased compression strength and stiffness, and controlled density modifications. Syntactic inclusions may include thermoplastics and thermosets, ceramics and metals, suitably though not exclusively as spheres. They may range in size from 5 or 10 thou in diameter up to 1 inch, for example, as appropriate to the particular application. Flame retardants, bacteriostats and fungicides, and inert fillers conferring modified physical characteristics, may also be incorporated.

The invention is not limited to the use of EPS granules. For example expanded polyethylene granules (eg Neopolen (Regd Trade

Mark) made by BASF) can be used. (These are normally supplied fully expanded, for bonding together by heating). With these granules, butadiene dissolved in an organic solvent has been used as the coating material, to give a tacky surface when dry.

Material in accordance with the present invention may be used in conjunction with conventional material. For example a moulding of conventional EPS material may have a layer of electrically conducting EPS produced by the present process moulded on to its surface.

The present invention also provides an expanded-plastics bonded-granule material when produced by a process as aforesaid.

The following are examples of moulded EPS material made in accordance with the present invention. The resistances were measured as prescribed in BS 2050. The latter defines "electrically conducting" as having an upper limit of resistance of  $5 \times 10^4$  ohms or less, and "anti-static" as having a resistance of over  $5 \times 10^4$  ohms and less than  $10^8$  ohms.

#### Example 1

Finely divided graphite powder (particle size approx 60-80 microns)	10g)	3g	
		(of mixture)	
Polychloroprene rubber aqueous emulsion	20g)		95
Pre-expanded EPS beads		5g	
Beads moulded while wet			100
Resistance:			
$7.9 \times 10^4$ ohms			

#### Example 2

Ditto powder	6g)	3g	105
		(of mixture)	
PVA aqueous emulsion	24g)		
Ditto beads		5g	
Beads moulded while wet			110
Resistance:			
$2.4 \times 10^5$ ohms			

#### Example 3

As Example 2 but beads dried before moulding, leaving 0.73 gm of dried mixture on the beads.  
Resistance:  $4.0 \times 10^5$  ohms.

The above weights are approximate. The mixture was applied by shaking with the beads in a polyethylene bag.

The following are two examples of moulded EPS material made by first coating the unexpanded granules (the "sugar"). It will be noted that they also disclose the use of polymers additional to those mentioned earlier as suitable for forming adherent films on the granules, viz polyvinyl acetate and ethyl cellulose; also that one

example uses an organic liquid vehicle, viz ethyl alcohol. Resistances were again measured as prescribed in BS 2050.

#### 5 Example 4

- |  |     |
|--|-----|
| Colloidal graphite (aqueous suspension, approx 23% solids by weight) | 10g |
| Polyvinyl acetate (aqueous emulsion, approx 50% solids by weight)    | 10g |
| Unexpanded EPS granules ("sugar")                                    | 25g |
| Resistance $4.2 \times 10^6$ ohms.                                   |     |

#### Example 5

- |                                   |      |              |
|-----------------------------------|------|--------------|
| 15 Ethyl cellulose (solid)        | 10g) |              |
| Ethyl alcohol                     | 50g) | 10g          |
|                                   |      | (of mixture) |
| 20 Colloidal graphite (as solid)  | 23g) |              |
| Unexpanded EPS granules ("sugar") |      | 100g         |
| Resistance                        |      |              |
| 25 $6.0 \times 10^6$ ohms.        |      |              |

In both these examples the granules were coated by shaking with a mixture of the other constituents in a polyethylene bag. They were then allowed to dry before heating in a known manner to the pre-expanded state, and then moulded in the usual way.

- Using either technique (ie coating either "beads" or "sugar") the resistance can be varied by varying the proportion of graphite included in the mixture. The quantity of liquid is not critical beyond promoting a uniform coating of the granules. A suitable mixture of constituents to confer a desired property can be determined experimentally in preliminary trials.

- It will be seen that the formulations given in all five of the above Examples can give resistances in the anti-static range. However for reasons which are not clear, the resistances obtained may vary very considerably from sample to sample despite using a constant formulation and constant processing conditions. It is found that substantially improved consistency in this respect is obtained with formulations which include a mixture of graphite powder and colloidal graphite, an example of which is as follows (all parts by weight):

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#### Example 6

- |  |          |
|--|----------|
| Graphite powder (particle size approx 60-80 microns)   | 12 parts |
| Colloidal graphite (aqueous suspension, particle size approx 1-2 microns, approx 25% solids by weight) | 4 parts  |
| PVA aqueous emulsion concentrate (approx 50% solids by weight)   | 10 parts |
| 65 Pre-expanded EPS granules   | 50 parts |

Coating was again effected by shaking the mixture in a polyethylene bag, after which the granules were allowed to dry before moulding in the usual way. Four successive samples using this formulation gave resistances of 1.7, 0.8, 1.2 and  $1.3 \times 10^6$  ohms respectively.

In Example 6 the sources of the materials were as follows:

Graphite powder — Luxara 3 brand, marketed by Arthur Bramwell Ltd. 75  
Colloidal graphite — Acheson Dag 554A  
PVA concentrate — Extrabond (Borden Chemical Co)

Pre-expanded granules coated with mixed powder/colloidal graphite formulations can also be bonded while still wet. Such mixed formulations are also suitable for coating unexpanded granules.

It may be noted incidentally that for resistances in the electrically-conducting range of BS 2050, more consistent results may be obtained with a mixture of graphite and a metal powder, eg silver, than with graphite alone.

A proportion of uncoated pre-expanded granules can be mixed with the coated pre-expanded granules prior to moulding, eg 1-0% of uncoated granules can be added. This admixture appears to improve the tensile strength of the molded material, and also permits the use of a "master-batch" of coated granules which can be mixed with a variable proportion of uncoated granules to control the degree of electrical conductivity, in the final moulded material. Master-batches of wholly unexpanded coated granules ("sugar") can also be prepared for mixing with uncoated unexpanded granules.

The present process is to be distinguished from merely coating the granules with a dry conducting powder, such as graphite, prior to bonding. The latter is unsatisfactory, *inter alia* because the resulting material is dirty to handle since the graphite is not bound to the granules. Incorporation of graphite by the present process produces a moulded material which is clean to handle.

#### WHAT I CLAIM IS:

1. A process for producing material which comprises expanded polymer granules bonded together, each said granule having been produced by expanding a smaller granule either before or during the present process, said process comprising the step of coating the granule surfaces, prior to bonding, with a solution or suspension which is compatible (as hereinbefore defined) with the granules and which, when dried, forms an adherent film on the granules, said solution or suspension incorporating an electrically conducting sub-

stance, either as a solute or as finely divided particles, which becomes bound within the dry adherent film.

2. A process as claimed in claim 1 wherein the expanded granules are expanded polystyrene granules.

3. A process as claimed in claim 1 or claim 2 wherein the solution or suspension comprises a polymer emulsion or a synthetic rubber latex.

4. A process as claimed in claim 3 wherein the polymer emulsion is a polyvinyl alcohol aqueous emulsion.

5. A process as claimed in claim 4 wherein the substance comprises particles of carbon or of a metal.

6. A process as claimed in any preceding claim wherein the coated granules are bonded together by heating in a mould.

7. A process as claimed in any of claims 1 to 6 wherein the solution or suspension is applied to the pre-expanded granules, which are thereafter fully explained and bonded.

8. A process as claimed in claim 7 wherein the thus-coated granules are dried before fully expanding and bonding the granules.

9. A process as claimed in any of claims 1 to 6 wherein the solution or suspension is applied to the wholly unexpanded granules, which are thereafter pre-expanded and subsequently fully expanded and bonded.

10. A process as claimed in claim 9 wherein the thus-coated granules are dried before pre-expanding and subsequently fully expanding and bonding.

11. A process as claimed in any preceding claim wherein, prior to bonding, the coated granules are mixed with a proportion of uncoated granules.

12. A process as claimed in claim 5 or any of claims 6 to 11 as dependent on claim 5, wherein the carbon is a mixture of graphite powder and colloidal graphite.

13. A process for producing a moulded expanded polystyrene granule packaging material having a resistance in the anti-static range (as specified in BS 2050), comprising coating the wholly unexpanded or the pre-expanded granules with a mixture comprising polyvinyl alcohol, graphite particles and colloidal graphite in an aqueous vehicle, and fully expanding and bonding the thus-coated granules by heating in a mould.

14. Material produced by a process as claimed in any of claims 1 to 8.

15. Material produced by a process as claimed in any of claims 9, 10 or 11.

16. Material produced by a process as claimed in claim 12.

17. Packaging material produced by a process as claimed in claim 13.

18. A process for producing a moulded material substantially as hereinbefore described with reference to Example 6.

19. A moulded material produced by a process substantially as hereinbefore described with reference to Example 6.

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